Technical Attachment

Widespread Wind Damage from 2 June 2004 Derecho in the ArkLaTex

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I. Introduction

Northwest flow is notorious for producing severe weather episodes in late spring into early summer in southwest Arkansas, northern Louisiana, and northeast Texas, commonly referred to as the ArkLaTex. Complexes of thunderstorms develop in the Plains with the aid of a nocturnal low level jet and interaction with a mid-level disturbance or frontal boundaries. These thunderstorms then usually propagate southeast not only toward the Shreveport (SHV) Weather Forecast Office (WFO) forecast area, but into a very moist and unstable environment. However, these complexes of storms usually arrive during the morning hours, which is typically when these mesoscale convective complexes (MCC) begin to weaken or dissipate all together. This weakening of the MCC is due to the dissipation of the nocturnal low-level jet and stabilization of the atmosphere. Residual boundaries left over from these complexes have the potential to help initiate thunderstorms later in the afternoon.

Around sunrise on June 2nd, the second of three complexes of storms that affected the area moved southeast out of the ArkLaTex. Subsidence behind this intense complex of storms allowed for plenty of insolation across the region with temperatures warming to near 90 degrees. These temperatures, combined with high dew points in the upper 60s and lower 70s, resulted in very unstable conditions south of an approaching cold front, which was located across northern Oklahoma and northwest Arkansas. In the afternoon of June 2nd, convection formed on the boundary across northern Oklahoma, and propagated southeast during the afternoon and early evening into the SHV WFO forecast area when the atmosphere was very unstable.

The derecho event was initiated by a weak shortwave trough in the northwest flow aloft and mesoscale forcing associated with the front. These storms surged southeast and moved through the ArkLaTex during the late afternoon into the evening producing a plethora of damage from straight-line winds as high as 85 mph.

II. Derecho Conceptual Model

By definition a “derecho” is a convective system that produces wind damage from gusts greater than 26 m s^{-1} (50 kt) for at least a length of 250 nautical miles. The damage reports from these high winds must also occur in a progressive pattern (nonrandom) with no more than a 3-hour gap between reports (Weisman 1993). Johns and Hirt (1987) describe two different synoptic patterns for derecho events. One synoptic pattern that leads to the formation of derecho events occurs typically during the winter and spring months associated with mid-latitude cyclones and associated strong cold fronts moving across the country. The other pattern is common in the late spring and summer with weak synoptic systems in westerly to northwesterly 500 mb flow. Over 75% of derecho events begin close to peak heating of the day along and to the north of a west to east oriented boundary (Johns 1987). In addition, “pooling” of low-level moisture near a quasi-stationary front is a common characteristic of derecho events (Johns 1987). Extreme instability and moderate wind shear are necessary along the track of the convective system in order to maintain itself long enough to be classified as a derecho event. Model simulations suggest the thermodynamic instability and vertical wind shear profile conducive for derecho events were convective available potential energy (CAPE) of 2000 J/kg or greater, with a wind shear of at least 20 m s^{-1} over the lowest 2.5 - 5 km AGL (Weisman 1993).

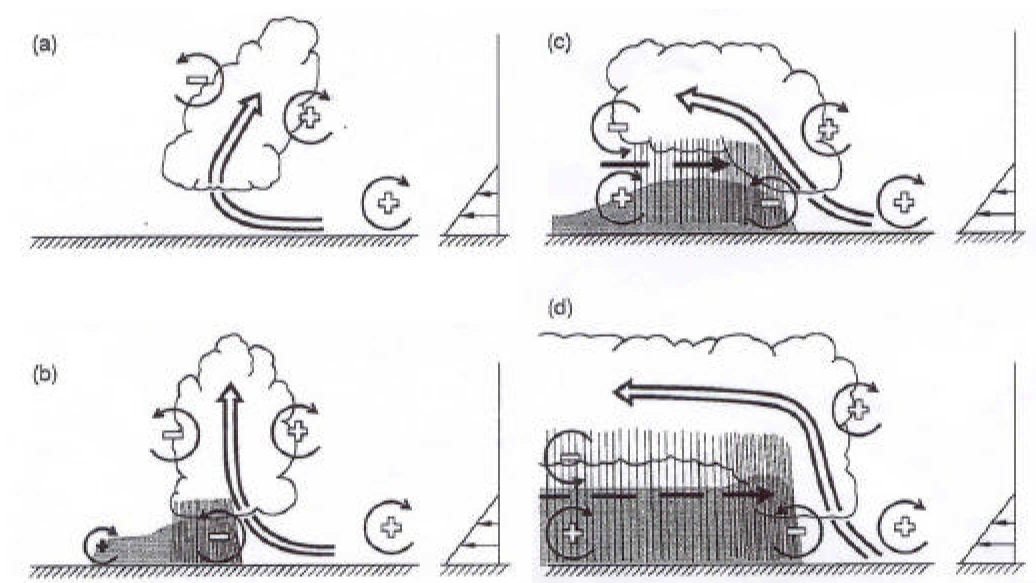

Figure 1. The four stages of the evolution of an idealized bow echo (Weisman 1993).

Once the environmental parameters come together to initiate a derecho event, there are storm scale processes that greatly impact the evolution of such an event. Weisman (1993) developed a schematic diagram showing four stages for an idealized bow echo (Figure 1). This scenario can also be applied to a squall line or derecho event. Initially, convection developing in a flow pattern with sufficient shear will tilt downshear from the ambient wind shear (Figure 1a). A cold pool will eventually develop beneath the storms generating a horizontal circulation opposite of the circulation generated by the ambient wind shear. This results in a more vertical updraft and stronger convection (Figure 1b). Eventually the cold pool circulation becomes stronger than the ambient wind shear circulation, and the updraft begins to tilt rearward (upshear) over the “cold pool” at the surface (Figure 1c). This is the third stage in an idealized bow echo evolution usually beginning after 2 hours. At this stage, an elevated rear-inflow jet (RIJ) begins to develop. The final stage (Figure 1d) is when the RIJ in combination with the ambient wind shear balances the cold pool circulation resulting in deeper lifting (more vertical updraft). However, enough instability and low-level vertical wind shear must be present to produce a RIJ strong enough, when combined with the ambient wind shear, to balance the circulation of the cold pool. Otherwise, the convection begins to decay as lifting along the gust front becomes weaker due to the cold pool circulation being the dominant circulation (Weisman 1993).

III. Analysis of the Environment

On the morning of June 2nd, surface analyses indicated a cold front from northern Oklahoma into northern Arkansas, and a decaying squall line across south central Mississippi and southeast Louisiana (Figure 2). Local 12 UTC soundings indicated that with daytime heating the atmosphere would become unstable by afternoon with Lifted Index values near -5 and CAPE near 2000 J/kg. Low level flow through 850 mb was generally weak, but moisture was already established south of the front with surface dew points in the lower to mid 60s. The pooling of moisture near the front was evident by the surface equivalent potential temperature (theta-e) gradient within one hundred miles of the front, decreasing from 352K in central OK to 324K near the Kansas border. In addition, there was an 850 mb theta-e ridge max just south of the frontal boundary of 332K to 340K. At 500 mb, weak disturbances were embedded in the west northwest flow across the region. The 500 mb flow near the frontal boundary in northern Oklahoma during the day on June 2nd was a bit stronger than usual for early summer between 40 and 50 kt, with 0 – 6 km shear between 20 and 25 m s^{-1}. Farther south into the ArkLaTex, the 0 – 6 km shear was only around 12.5 m s^{-1}. In addition, the Southern Plains was in the right rear quadrant of an 80 kt jet streak.

During the morning, ongoing convection was north of the boundary in northern Oklahoma and southern Kansas with abundant solar insolation south of the boundary. In the wake of the previous night's severe convection across east Texas and north Louisiana, strong subsidence only allowed a few cumulus clouds to form despite temperatures near 90 and dew points in the mid 60s to near 70. A weak disturbance in the northwest flow, in combination with some upper level divergence and temperatures rising into the mid to upper 80s, helped break a small capping inversion (CAP) south of the frontal boundary across east central Oklahoma, allowing scattered to numerous thunderstorms to develop by midday. These thunderstorms quickly became a squall line and headed south southeast toward the ArkLaTex in the northwest flow aloft.

These thunderstorms were moving into an increasingly unstable environment. By mid afternoon, CAPE values were near 3500 J/kg, with lifted index values near -10 ahead of the approaching squall line. LAPS surface helicity was on the low side, with values between 50 and 75 m^2/s^2. Ahead of the destructive squall line, Shreveport's 00 UTC 3 June 2004 sounding indicated a very unstable atmosphere with a LI of -9, CAPE of 3000 J/kg, SWEAT of 526, and Total Totals of 57. Additionally, there was high moisture content with 1.72 inches of precipitable water. The 0 to 3 km helicity was only 64 m^2/s^2.

IV. Model Data

The 00 UTC 2 June 2006 GFS, NAM, and NGM models did indicate the initial squall line development late in the evening on 1 June 2004. This squall line formed around 04 UTC 2 June 2004 over northeast Texas, moving through east Texas and much of Louisiana during the early morning of 2 June 2004. Therefore, instead of scattered thunderstorms as predicted by all three models for the daytime on 2 June 2004, intense insolation with no convection occurred across the region. This occurred due to subsidence in the wake of the severe line of thunderstorms in combination with a weak CAP in place. The convection that formed around midday on 2 June 2004 was closer to the front in Oklahoma and Arkansas where the CAP was more easily broken. Models did indicate if convection formed, it would move southeast in the northwest flow aloft. LAPS and MSAS data in the afternoon revealed the squall line was moving into an extremely unstable atmosphere which could sustain the squall line through the area despite outrunning the front and upper level dynamics.

V. Radar Data

The squall line entered McCurtain County in southeast Oklahoma around 2220 UTC 2 June 2004 and exited the southeast part of the SHV CWA by around 05 UTC 3 June 2004. This line of storms, when it was moving through southwest Arkansas into extreme northeast Texas, was **350 miles long** and about 30 miles wide (Figure 3). It extended from Mount Ida, Arkansas, through Texarkana to Wichita Falls, Texas. A few Mid-Altitude Radial Convergence (MARC) signatures were present as these storms moved through southeast Oklahoma and southwest Arkansas (Figures 4 and 5). These signatures were quite strong with 110 knots of convergence between 10 and 15 thousand feet. Base velocities began to show strong inbound winds as the line of storms moved to within 65 miles of the Shreveport WSR-88D. The Shreveport WSR-88D estimated 75 knots of wind toward the radar around 7000 feet. An observed wind of 58 kts (67 mph) was recorded at Texarkana Regional Webb Field at 0007 UTC 3 June 2004. The base velocity image around the same time indicated 80 kts of inbound velocities just west into Bowie County between Texarkana and New Boston with around 55 kts of inbound velocities near Texarkana.

Reflectivity was not as intense across east Texas, but an intense gust front pushed well ahead of the line of storms. This was most likely the result of the cold pool circulation of the derecho dominating the ambient wind shear across east Texas. **The gust front probably did as much or more damage than the actual line of storms across east Texas**. Gregg County Airport (GGG) recorded a peak wind speed of 42 knots at 0117 UTC 3 June 2004, while the convection was still 15 miles to the north on the Gregg and Upshur County line (Figure 6). Tyler Pounds Field ASOS equipment malfunctioned as the gust front pushed through. However, FAA personnel estimated a gust to 45 knots well ahead of the storms. Radar and ASOS data also shows clearly that Downtown Shreveport (DTN) had its highest wind speed before the line of storms. Although, the line of storms and gust front were much closer together across northwest Louisiana where more ambient wind shear was present. This is not to say wind damage did not occur within the storms across east Texas, but the data suggests most of the strongest winds across east Texas occurred along the gust front.

VI. Damage Reports

Widespread wind damage was reported with this derecho event. An estimated **2.2 million** dollars of damage occurred in the WFO Shreveport's area of responsibility. Wind was by far the primary cause of damage with only a few hail reports. The ratio was roughly seven to one. The worst damage occurred across southwest Arkansas and parts of northeast Texas and north Louisiana. One fatality occurred in Franklin County in northeast Texas when a tree fell on top of a mobile home. Another 6 people were known to be injured during this event. Interstate 30 was closed from Hope to Prescott Arkansas due to downed trees and overturned trucks. Other state highways in Arkansas were also closed for the same reason. The Union Parish Office of Emergency Preparedness declared a state of emergency for the entire parish due to widespread damage caused by downed trees. Wind damage occurred in 47 out of 48 counties and parishes in WFO Shreveport's CWA.

VII. Conclusion

Although the environment for intense organized storms was not favorable (lack of wind shear) across Shreveport's forecast area June 2nd, the atmosphere just to the north had the necessary ingredients for explosive development once convective temperatures were met. As the thunderstorms across north Oklahoma developed, they quickly evolved into a line and moved southeast in the northwest flow into an area of strong instability. The gust front outrunning the line of convection across east Texas suggested that the cold pool circulation dominated the environmental ambient shear.

This event further highlights the need for meteorologists to have and maintain situational awareness during severe weather events. In this case, warnings were needed well ahead of the derecho in east Texas along the distinct gust front. A best practice is to include specific wording about the gust front in the warnings. For example, WFO Shreveport uses the canned statement "Wind damage with this line of storms will occur well ahead of any rain or lightning. Do not wait for the sound of thunder before taking cover". If a severe gust front or outflow boundary moves too far from the parent thunderstorm complex to justify a severe thunderstorm warning, a high wind warning might be appropriate.

VIII. References

Johns, R. H., and W. D. Hirt, 1987: Derechos: widespread convectively induced windstorms. *Weather and Forecasting*, **2**, 32-49.

Weisman, Dr. Morris L., 1993: The Genesis of Severe, Long-Lived Bow Echoes *Journal of the Atmospheric Sciences*, **50**, 645-670.

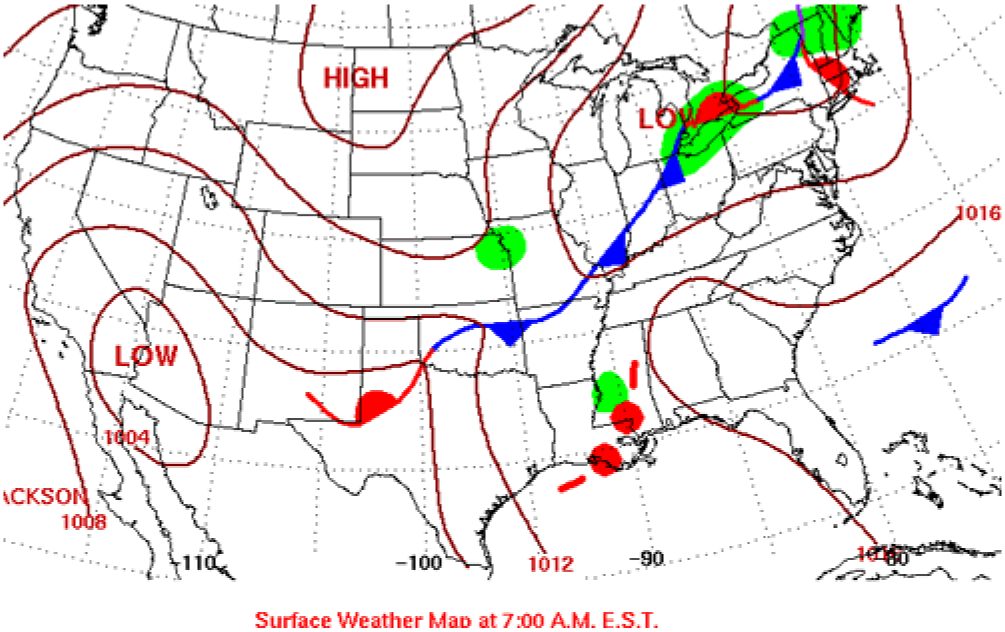

Figure 2. The surface weather analysis for 12 UTC 2 June 2004. It shows an exiting squall line across Mississippi and southeast Louisiana and a quasi-stationary front across northern Oklahoma.

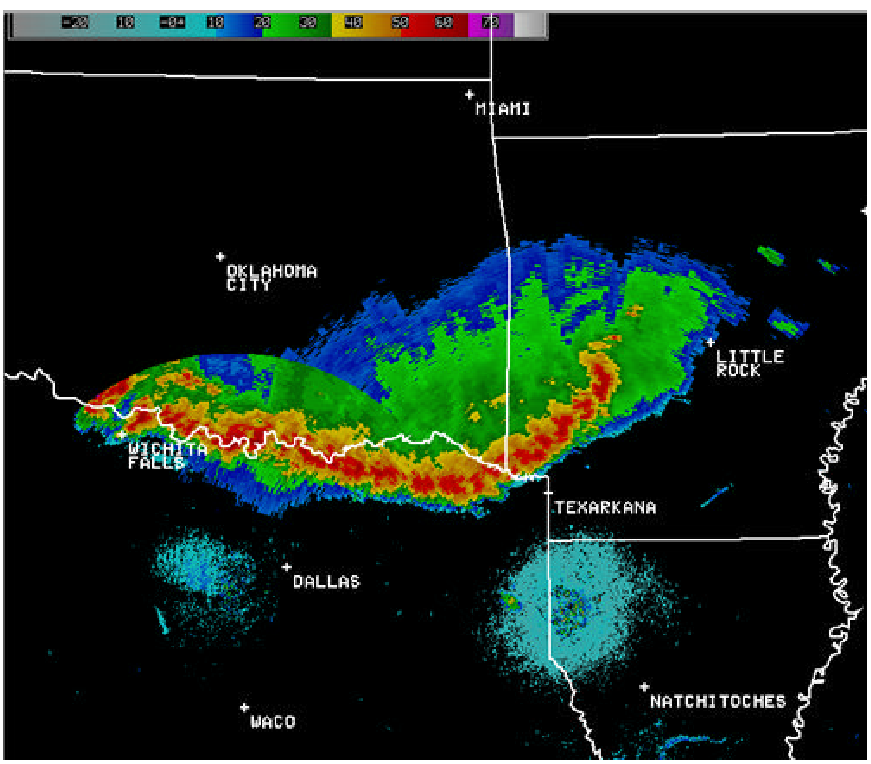

Figure 3. A radar mosaic of the 350 mile long severe squall line during the evening of 2 June 2004.

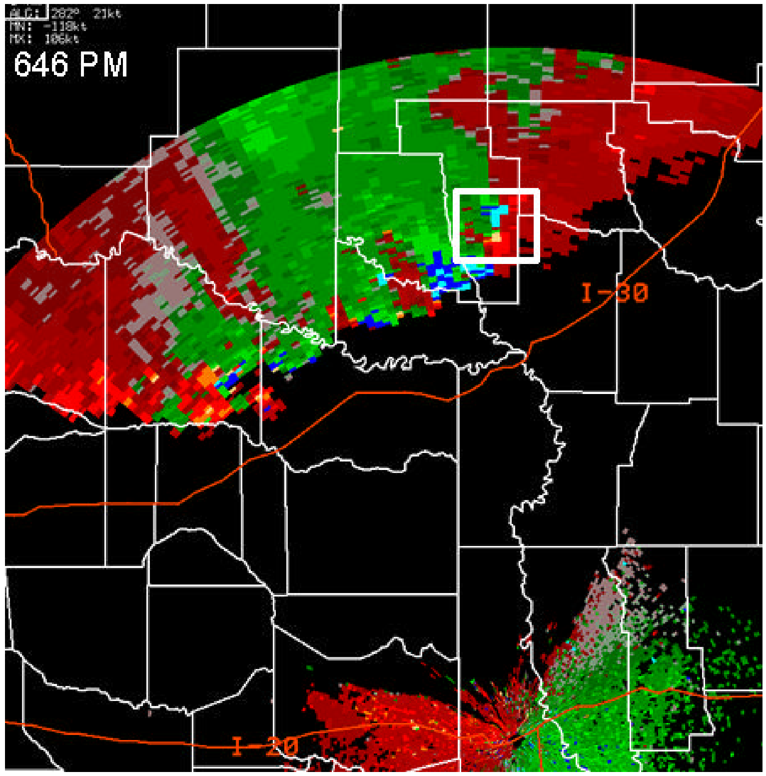

Figure 4. A mid-altitude radial convergence (MARC) signature present in the storm-relative motion velocity product taken at 2346 UTC on 2 June 2004.

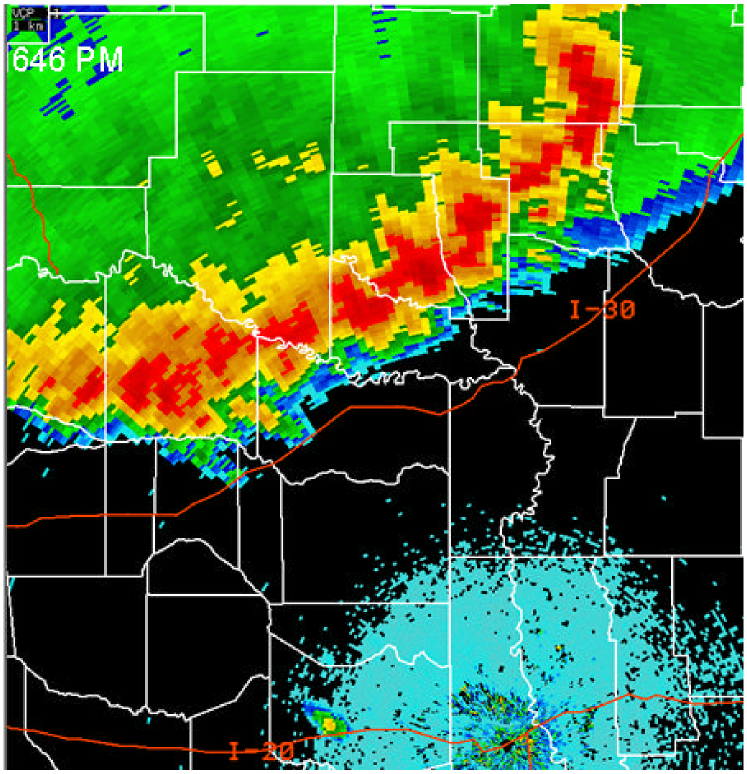

Figure 5. A reflectivity image at the same time the MARC signature is present in Figure 4.

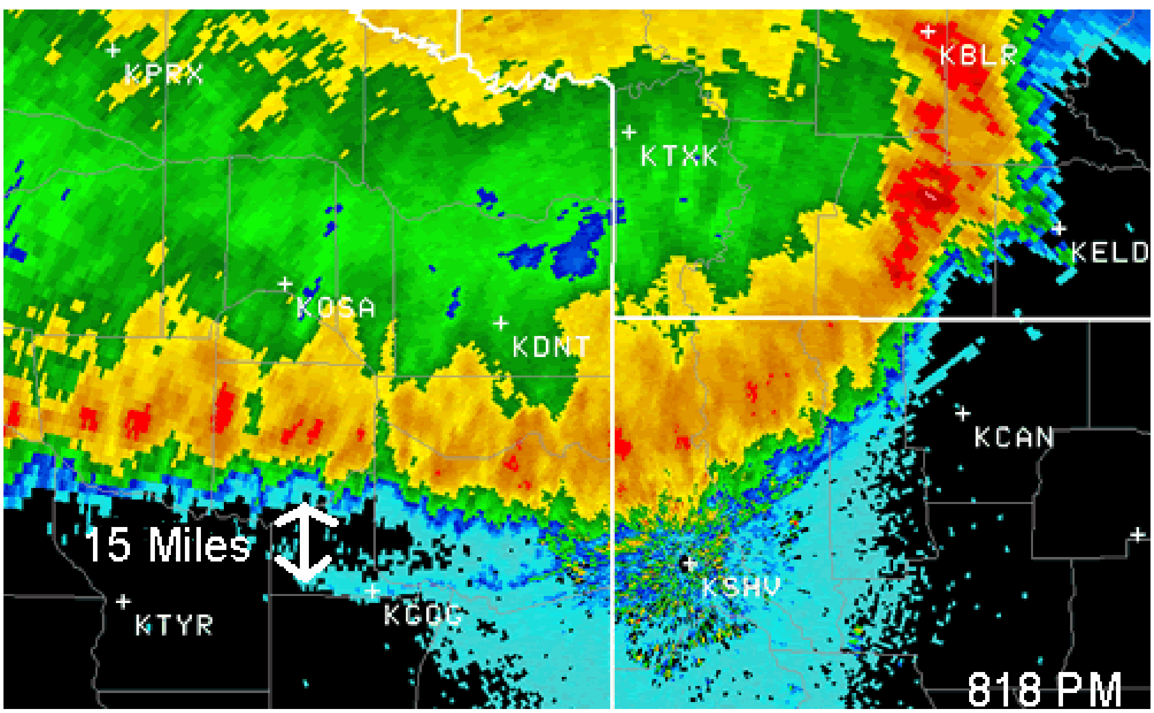

Figure 6. The reflectivity image at 0118 UTC 3 June 2004 showing the gust front 15

miles ahead of the line of thunderstorms. At the same time (0117 UTC) Gregg County Airport (KGGG) recorded a wind gust of 42 knots. That was the highest gust for KGGG during this event.